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SUBSCRIBER INTEGRATED ACCESS DEVICE FOR USE IN WIRELESS AND WIRELINE ACCESS SYSTEMS

TECHNICAL FIELD OF THE INVENTION

The present invention is directed, in general, to communication network access systems and, more specifically, to a subscriber integrated access device for accessing wireless, cable, and wired voice frequency (VF) access systems.

BACKGROUND OF THE INVENTION

Telecommunications access systems provide for voice, data, and multimedia transport and control between the central office (CO) of the telecommunications service provider and the subscriber (customer) premises. Prior to the mid-1970s, the subscriber was provided phone lines (e.g., voice frequency (VF) pairs) directly from the Class 5 switching equipment located in the central office of the telephone company. In the late 1970s, digital loop carrier (DLC) equipment was added to the telecommunications access architecture. The DLC equipment provided an analog phone interface, voice CODEC, digital data multiplexing, transmission interface, and control and alarm remotely from the central office

to cabinets located within business and residential locations for approximately 100 to 2000 phone line interfaces. This distributed access architecture greatly reduced line lengths to the subscriber and resulted in significant savings in both wire installation and maintenance. The reduced line lengths also improved communication performance on the line provided to the subscriber.

By the late 1980s, the limitations of data modem connections over voice frequency (VF) pairs were becoming obvious to both subscribers and telecommunications service providers. ISDN (Integrated Services Digital Network) was introduced to provide universal 128 kbps service in the access network. The subscriber interface is based on 64 kbps digitization of the VF pair for digital multiplexing into high speed digital transmission streams (e.g., T1/T3 lines in North America, E1/E3 lines in Europe). ISDN was a logical extension of the digital network that had evolved throughout the 1980s. The rollout of ISDN in Europe was highly successful. However, the rollout in the United States was not successful, due in part to artificially high tariff costs which greatly inhibited the acceptance of ISDN.

More recently, the explosion of the Internet and deregulation of the telecommunications industry have brought about a broadband revolution characterized by greatly increased demands for both voice and data services and greatly reduced costs due to

technological innovation and intense competition in the telecommunications marketplace. To meet these demands, high speed DSL (digital subscriber line) modems and cable modems have been developed and introduced. The DLC architecture was extended to provide remote distributed deployment at the neighborhood cabinet level using DSL access multiplexer (DSLAM) equipment. The increased data rates provided to the subscriber resulted in upgrade DLC/DSLAM transmission interfaces from T1/E1 interfaces (1.5/2.0 Mbps) to high speed DS3 and OC3 interfaces. In a similar fashion, the entire telecommunications network backbone has undergone and is undergoing continuous upgrade to wideband optical transmission and switching equipment.

Similarly, wireless access systems have been developed and deployed to provide broadband access to both commercial and residential subscriber premises. Initially, the market for wireless access systems was driven by rural radiotelephony deployed solely to meet the universal service requirements imposed by government (i.e., the local telephone company is required to serve all subscribers regardless of the cost to install service). The cost of providing a wired connection to a small percentage of rural subscribers was high enough to justify the development and expense of small-capacity wireless local loop (WLL) systems.

Deregulation of the local telephone market in the United

States (e.g., Telecommunications Act of 1996) and in other countries shifted the focus of fixed wireless access (FWA) systems deployment from rural access to competitive local access in more urbanized areas. In addition, the age and inaccessibility of much of the older wired telephone infrastructure makes FWA systems a cost-effective alternative to installing new, wired infrastructure. Also, it is more economically feasible to install FWA systems in developing countries where the market penetration is limited (i.e., the number and density of users who can afford to pay for services is limited to small percent of the population) and the rollout of wired infrastructure cannot be performed profitably. In either case, broad acceptance of FWA systems requires that the voice and data quality of FWA systems must meet or exceed the performance of wired infrastructure.

Wireless access systems must address a number of unique operational and technical issues including:

1) Relatively high bit error rates (BER) compared to wire line or optical systems; and

2) Transparent operation with network protocols and protocol time constraints for the following protocols:

a) ATM;

b) Class 5 switch interfaces (domestic GR-303 and international V5.2);

c) TCP/IP with quality-of-service QoS for voice over IP (VoIP) (i.e., RTP) and other H.323 media services;

d) Distribution of synchronization of network time out to the subscribers;

3) Increased use of voice, video and/or media compression and concentration of active traffic over the air interface to conserve bandwidth;

4) Switching and routing within the access system to distribute signals from the central office to multiple remote cell sites containing multiple cell sectors and one or more frequencies of operation per sector; and

5) Remote support and debugging of the subscriber equipment, including remote software upgrade and provisioning.

Unlike physical optical or wire systems that operate at bit error rates (BER) of 10^{-11}, wireless access systems have time varying channels that typically provide bit error rates of 10^{-3} to 10^{-6}. The wireless physical (PHY) layer interface and the media access control (MAC) layer interface must provide modulation, error correction and ARQ protocol that can detect and, where required, correct or retransmit corrupted data so that the interfaces at the network and at the subscriber site operate at wire line bit error rates.

The wide range of equipment and technology capable of providing either wireline (i.e., cable, DSL, optical) broadband access or wireless broadband access has allowed service providers to match the needs of a subscriber with a suitable broadband access solution. However, in many areas, the cost of cable modem or DSL service is high. Additionally, data rates may be slow or coverage incomplete due to line lengths. In these areas and in areas where the high cost of replacing old telephone equipment or the low density of subscribers makes it economically unfeasible to introduce either DSL or cable modem broadband access, fixed wireless broadband systems offer a viable alternative. Fixed wireless broadband systems use a group of transceiver base stations to cover a region in the same manner as the base stations of a cellular phone system. The base stations of a fixed wireless broadband system transmit forward channel (i.e., downstream) signals in directed beams to fixed location antennas attached to the residences or offices of subscribers. The base stations also receive reverse channel (i.e., upstream) signals transmitted by the broadband access equipment of the subscriber.

Unfortunately, the diversity of broadband access technology has resulted in a lack of standardization in the broadband access equipment. Cable modems and DSL routers are incompatible with each other and with fiber optic equipment. Different service providers

locate broadband access equipment in different locations on the subscriber premises. Often this equipment is located inside the office or residence of the subscriber, which makes it inaccessible to maintenance workers unless the subscriber is present to admit the workers to the premises. The lack of standardization of broadband access equipment and the frequent inaccessibility of such equipment adds to the cost and complexity of broadband access.

Therefore, there is a need in the art for broadband access equipment that can be readily and inexpensively deployed in the large domestic and international markets that are not currently served by wired or wireless broadband access technology. In particular, there is a need for broadband access equipment that provides competitive local exchange carriers (CLECs) a highly cost-effective turnkey facility solution that significantly improves profit margins and service quality. More particularly, there is a need for a subscriber integrated access device that may be easily and inexpensively installed and accessed at the subscriber's premises and that is compatible with different types of wireline and wireless broadband access technologies.

SUMMARY OF THE INVENTION

To address the above-discussed deficiencies of the prior art, it is a primary object of the present invention to provide, for use in association with a subscriber premises, an apparatus for providing broadband access to a fixed wireless network. According to an advantageous embodiment of the present invention, the apparatus comprises: 1) a subscriber access device capable of being mounted on an exterior portion of the subscriber premises, the subscriber access device comprising a wireless transceiver capable of communicating with the fixed wireless network and at least one of a data interface capable of communicating with a data processing device within the subscriber premises and a voice interface capable of communicating with a telephony device within the subscriber premises; and 2) a backup power supply capable of providing power to the subscriber access device in the event of a failure of main AC power in the subscriber premises.

According to one embodiment of the present invention, the backup power supply is disposed within the subscriber premises.

According to another embodiment of the present invention, the backup power supply is disposed outside the subscriber premises.

According to still another embodiment of the present invention, the apparatus further comprises a power monitor capable

of detecting at least one of: 1) a low power condition on the backup power supply and 2) the failure of the main AC power and, in response to the detection, transmitting an alarm to the fixed wireless network via the subscriber access device.

According to yet another embodiment of the present invention, the apparatus further comprises a mezzanine interface coupled to the wireless transceiver and capable of receiving a removable module capable of communicating with the data processing device.

According to a further embodiment of the present invention, the removable module comprises a T1/E1 module capable of communicating via a T1/E1 line within the subscriber premises.

According to a still further embodiment of the present invention, the removable module comprises a T3/E3 module capable of communicating via a T3/E3 line within the subscriber premises.

According to yet further embodiment of the present invention, the removable module comprises a wireless LAN transceiver capable of communicating wirelessly with the data processing device.

In one embodiment of the present invention, the data interface is capable of communicating with the data processing device within the subscriber premises using a dedicated data networking interface.

In another embodiment of the present invention, the data interface is capable of communicating with the data processing

device within the subscriber premises using an Ethernet network protocol.

In still another embodiment of the present invention, the data interface is one of a 10Base-T Ethernet interface, a 100Base-T Ethernet interface, and a 1000Base-T Ethernet interface.

In yet another embodiment of the present invention, the data interface is capable of communicating with the data processing device within the subscriber premises using a shared voice/data home wiring twisted pair system.

In a further embodiment of the present invention, the shared voice/data home wiring twisted pair system comprises a Home Phone Network Alliance (HPNA) protocol.

It also is a primary object of the present invention to provide, for use in association with a subscriber premises, an apparatus for providing broadband access to a wireline network. According to an alternate advantageous embodiment of the present invention, the apparatus comprises: 1) a subscriber access device capable of being mounted on an exterior portion of the subscriber premises, the subscriber access device comprising a wireline transceiver interface capable of communicating with the wireline network and at least one of a data interface capable of communicating with a data processing device within the subscriber premises and a voice interface capable of communicating with a

telephony device within the subscriber premises; and 2) a backup power supply capable of providing power to the subscriber access device in the event of a failure of main AC power in the subscriber premises.

The foregoing has outlined rather broadly the features and technical advantages of the present invention so that those skilled in the art may better understand the detailed description of the invention that follows. Additional features and advantages of the invention will be described hereinafter that form the subject of the claims of the invention. Those skilled in the art should appreciate that they may readily use the conception and the specific embodiment disclosed as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

Before undertaking the DETAILED DESCRIPTION OF THE INVENTION below, it may be advantageous to set forth definitions of certain words and phrases used throughout this patent document: the terms "include" and "comprise," as well as derivatives thereof, mean inclusion without limitation; the term "or," is inclusive, meaning and/or; the phrases "associated with" and "associated therewith," as well as derivatives thereof, may mean to include, be included

within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like; and the term "controller" means any device, system or part thereof that controls at least one operation, such a device may be implemented in hardware, firmware or software, or some combination of at least two of the same. It should be noted that the functionality associated with any particular controller may be centralized or distributed, whether locally or remotely. Definitions for certain words and phrases are provided throughout this patent document, those of ordinary skill in the art should understand that in many, if not most instances, such definitions apply to prior, as well as future uses of such defined words and phrases.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, wherein like numbers designate like objects, and in which:

FIGURE 1 illustrates exemplary fixed wireless access network according to one embodiment of the present invention;

FIGURE 2 illustrates exemplary subscriber premises in which subscriber integrated access device (IAD) according to the principles of the present invention is installed;

FIGURE 3 depicts exemplary subscriber integrated access device (IAD) in greater detail according to one embodiment of the present invention; and

FIGURES 4A-4C illustrates a DC battery and subscriber integrated access device in greater detail according to several embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIGURES 1 through 4, discussed below, and the various embodiments used to describe the principles of the present invention in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the invention. Those skilled in the art will understand that the principles of the present invention may be implemented in any suitably arranged subscriber integrated access device.

FIGURE 1 illustrates exemplary fixed wireless access network 100 according to one embodiment of the present invention. Fixed wireless network 100 comprises a plurality of transceiver base stations, including exemplary transceiver base station 110, that transmit forward channel (i.e., downstream) broadband signals to a plurality of subscriber premises, including exemplary subscriber premises 121, 122 and 123, and receive reverse channel (i.e., upstream) broadband signals from the plurality of subscriber premises. Subscriber premises 121-123 transmit and receive via fixed, externally-mounted antennas 131-133, respectively. Subscriber premises 121-123 may comprise many different types of residential and commercial buildings, including single family homes, multi-tenant offices, small business enterprises (SBE), medium business enterprises (MBE), and so-called "SOHO" (small

office/home office) premises.

The transceiver base stations, including transceiver base station 110, receive the forward channel signals from external network 150 and transmit the reverse channel signals to external network 150. External network 150 may be, for example, the public switched telephone network (PSTN) or one or more data networks, including the Internet or proprietary Internet protocol (IP) wide area networks (WANs) and local area networks (LANs). Exemplary transceiver base station 110 is coupled to RF modem 140, which, among other things, up-converts baseband data traffic received from external network 150 to RF signals transmitted in the forward channel to subscriber premises 121-123. RF modem 140 also down-converts RF signals received in the reverse channel from subscriber premises 121-123 to baseband data traffic that is transmitted to external network 150. In an exemplary embodiment of the present invention in which external network 150 is the public switched telephone network (PSTN), RF modem 140 transmits baseband data traffic to, and receives baseband data traffic from, access processor 165, which is disposed in central office facility 160 of the PSTN.

It should be noted that network 100 was chosen as a fixed wireless network only for the purposes of simplicity and clarity in explaining a subscriber integrated access device according to the

principles of the present invention. The choice of a fixed wireless network should not be construed in any manner that limits the scope of the present invention in any way. As will be explained below in greater detail, in alternate embodiments of the present invention, a subscriber integrated access device according to the principles of the present invention may be implemented in other types of broadband access systems, including wireline systems (i.e, digital subscriber line (DSL), cable modem, fiber optic, and the like) in which a wireline connected to the subscriber integrated access device carries forward and reverse channel signals.

FIGURE 2 illustrates exemplary subscriber premises 121 in which subscriber integrated access device (IAD) 210 according to the principles of the present invention is implemented. Subscriber IAD 210 is connected to one or more communication devices in subscriber premises 121 via network termination (NT) 220 or (optionally) via a wireless local area network (LAN) connection. Subscriber premises 121 may contain one or more processing devices, such as exemplary personal computers 231, 232, 233 and 234, and one or more telephones, including exemplary telephones 241, 242 and 243, that are capable of communicating via the broadband access capability of fixed wireless access network 100.

NT 220 is the external point to which data lines and phone

lines within a residence or office are brought in order to be connected to the local telephone service provider. AC/DC converter 290 converts the main AC power in subscriber premises 121 to primary DC power that powers subscriber IAD 210. In order to comply with government regulations for telephone service to one or more telephones in subscriber premises 121, DC battery 261 is charged from the DC output of AC/DC converter 290 in order to provide at least eight hours of backup power in case of a failure of the AC main power in subscriber premises 121. Battery monitor (BM) 262 in subscriber IAD 210 detects main AC power failures and detects low power conditions on DC battery 261 and transmits alarms to fixed wireless access network 100 through subscriber IAD 210.

In an alternate embodiment of the present invention, DC battery 261 may be located inside subscriber premises 121 (as shown by dotted lines), rather than mounted on the outside of subscriber premises 121. However, in a preferred embodiment of the present invention, DC battery 261 is externally mounted in order to give maintenance personnel easy access to nearly all components of the subscriber access system (i.e., subscriber IAD 210, DC battery 261 antenna 131) without requiring the homeowner to be present. Although AC/DC converter 290 is disposed in subscriber premises 121, this does not present a problem. Conventional AC/DC converters have very large mean time between failure (MTBF)

ratings, so that failures are rare. Furthermore, AC/DC converters are common, inexpensive commercial products that may be purchased and easily installed by the subscriber without the assistance of maintenance personnel. As will be described below in greater detail, since DC battery 261 is often mounted on the outside of subscriber premises 121, DC battery 261 may comprise an internal tamper alarm circuit that transmits an alarm to battery monitor 262 if DC battery 261 is opened or otherwise tampered with by someone other than maintenance personnel.

FIGURE 3 depicts exemplary subscriber integrated access device (IAD) 210 in greater detail according to one embodiment of the present invention. Subscriber IAD 210 is an external unit capable of, for example, radio frequency down-conversion, protocol conversion, voice decompression and control functions. As noted above, the entire subscriber IAD system comprises three major elements:

1) external antenna 131 allows for multiple antenna options for increased gain or multiple element antenna subsystems;

2) subscriber IAD 210 main assembly contains the integrated printed circuit board (PCB) motherboard and a mezzanine interface into which an optional expansion module may be inserted to provide, for example, two additional voice frequency (VF) pairs, a T1/E1 module, or a TE/E3 module for use in a SOHO premises, a

small/medium enterprise (SME) premises, or a multi-tenant unit (MTU) premises; and

3) DC battery 261 and AC/DC converter 290, which may be deployed inside or (preferably) outside subscriber premises 121 to provide at least eight (8) hours of operation without AC main power.

Subscriber IAD 210 is connected directly to some subscriber premises equipment (i.e., PC 231-233, telephones 241-243) to provide direct access to voice and broadband data in fixed wireless access network 100 at the NT 220 demarcation point at the customer premise. Both product cost and life-cycle/installation costs are reduced by integrating voice and data interfaces into a single external unit that connects to the standard NT 220 interface at the subscriber premises. Optionally, subscriber IAD 210 may also communicate wirelessly with some subscriber premises equipment, such as PC 234, via a wireless LAN connection. As will be explained below, subscriber IAD 210 may wirelessly transmit data to and receive data from PC 234 via antenna 295. Similarly, PC 234 may wirelessly transmit data to and receive data from subscriber IAD 210 via antenna 292.

In an advantageous embodiment of the present invention, subscriber IAD 210 may provide at least four data interface options, including:

1) separate Cat-5 twisted pairs for 10Base-T Ethernet;

2) one of the VF pairs may be used with, for example, a 1 Mbps or 10 Mbps Home Phone Network Alliance (HPNA) interface or other shared voice/data home wiring twisted pair system;

3) home power line interface with release of higher bandwidth implementations (> 1Mbps); and

4) wireless LAN connection to subscriber premises equipment.

In an advantageous embodiment, subscriber IAD 210 comprises RF interface (IF) 305, control/networking PAD/voice processing circuitry 310, DC/DC converter 315, battery monitor 262, and mezzanine interface 320. In a fixed wireless embodiment, RF IF 305 provides modulation and demodulation of forward and reverse channel signals between transceiver base station 110 and subscriber IAD 210. DC/DC converter 315 converts the external DC power received from battery 261 to the necessary internal DC power levels used by the components of subscriber IAD 210. Battery monitor 262 monitors the battery power from DC battery 261 and receives alarm signals, if any, from DC battery 261.

If main AC power fails, or if DC battery 261 is tampered with, DC battery 261 transmits alarm signals to battery monitor 262. If the DC power level from DC battery falls too low after an AC power failure, battery monitor 262 detects the low DC power level condition and generates an alarm. The alarms generated by or

received by battery monitor 262 are sent to control/networking PAD/voice processing circuitry 310 in order to be transmitted back to the fixed wireless service provider.

In a standard (and low cost) configuration, control/networking PAD/voice processing circuitry 310 comprises, among other things, two voice frequency (VF) pair interface (IF) 312 and data interface (IF) 325. Control/networking PAD/voice processing circuitry 310 performs the overall control functions of subscriber IAD 210 and converts reverse channel voice and data signals received from telephones 241-243 and PC 231-233 to the necessary protocols for transmission to transceiver base station 110 via RF IF 305. Similarly, control/networking PAD/voice processing circuitry 310 converts forward channel signals received from transceiver base station 110 via RF IF 305 to voice and data signals that are used by telephones 241-243 and PC 231-233.

In alternate wireline embodiments of the present invention, subscriber IAD 210 may also comprise an expansion slot for one or more wireline interfaces, including for example, cable modem 330. Alternative wireline interfaces may include an optical interface, a DSL router, or the like, in addition to, or in place of, RF IF 305. Cable modem 330 (or an optical interface or a DSL router) provide external interface connection points for a cable modem data line, a fiber optic line, and a DSL line, respectively.

As noted above, in an advantageous embodiment of the present invention, mezzanine IF 320 receives expansion module 321 in order to provide additional capabilities to subscriber IAD 210, particularly to meet the needs of small-medium business enterprises and multi-tenant units. For example, expansion module 321 may comprise a voice frequency pair interface, similar to two VF IF 312, providing subscriber IAD 210 with a total capability or four voice lines and one data line (4V/1D).

In a second embodiment, expansion module 321 may comprise a T1/E1 interface. In a third embodiment, expansion module 321 may comprise a T3/E3 interface. In a fourth embodiment, expansion module 321 may comprise a DSL or cable modem interface.

Finally, in a wireless LAN embodiment, expansion module 321 may comprise a wireless transceiver interface that communicates with PC 234 via antenna 295. In the illustrated embodiment, antenna 295 is an integral component of subscriber IAD 210 that is coupled to a connection pin on mezzanine IF 320. In such an embodiment, expansion module 321 comprises conventional RF transceiver circuitry, but does not require its own antenna. However, in an alternate embodiment, antenna 295 may be an integral component of expansion module 321, such that subscriber IAD 210 does not contain a separate antenna for wireless LAN purposes.

FIGURES 4A-4C illustrates DC battery 261 and subscriber

IAD 210 in greater detail according to several embodiments of the present invention. In FIGURE 4A, DC battery 261 comprises charge circuit 405, battery cell 410, and battery alarm detector 415. Charge circuit 405 receives the output of AC/DC converter 290 and applies a charge to battery cell 410. The DC power is then sent to subscriber IAD 210 via power/ground pair 420. Battery alarm detector 415 detects the opening of DC battery 261 and transmits an alarm signal to subscriber IAD 210 via signal line pair 425 (i.e., data line and clock line).

FIGURE 4B depicts an alternate embodiment for transmitting alarm signals to subscriber IAD 210. DC battery 261 is similar in most respects except that alarm signals are transmitted to subscriber IAD 210 via serial data line 430. FIGURE 4C depicts yet another embodiment for transmitting alarm signals to subscriber IAD 210. DC battery 261 is similar in most respects except that battery alarm detector 415 transmits alarm signals to charge circuit 405. Charge circuit 405 then transmits an alarm signal (e.g., a pulse signal) to subscriber IAD 210 on power/ground pair 420 along with the DC power. Charge circuit 405 may use one type of alarm signal to indicate that main AC power has failed and another type of alarm signal to indicate that DC battery 261 has been tampered with.

Although the present invention has been described in detail,

those skilled in the art should understand that they can make various changes, substitutions and alterations herein without departing from the spirit and scope of the invention in its broadest form.